Kavli IPMU-Berkeley Symposium
"Statistics, Physics and Astronomy"
January 11--12, 2018
Lecture Hall, Kavli IPMU

Program

January 11 (Thursday)

14:00 -- 15:00
Shiro Ikeda (The Institute of Statistical Mathematics)
Statistical signal processing for astronomy
15:30 -- 16:30
Masanao Ozawa (Nagoya University)
Quantum Measurement Theory,
the Uncertainty Principle and Gravitational Wave Detection: A Crossroad
16:40 -- 17:40
Philip B. Stark (UC Berkeley)
Quantifying Uncertainty in Inferences in Physics and Astronomy

January 12 (Friday)

14:00 -- 15:00
Alessandro Sonnenfeld (Kavli IPMU)
Bayesian hierarchical inference in astronomy
15:30 -- 16:30
Ippei Obayashi (AIMR Tohoku University)
Introduction to topological data analysis
16:40 -- 17:40
Wahid Bhimji (LBNL Berkeley)
Deep learning for HEP and Cosmology

Abstracts

Shiro Ikeda

Title: Statistical signal processing for astronomy

Abstract:

Since the goal of astronomy is to understand the celestial objects through limited observed information, there are a lot of inverse problems in astronomy. On the other hand, recent developments in data science, such as sparsity based methods, provide powerful tools to tackle some of those problems. We have developed "Sparse-imaging tools" for VLBI (Very Long Baseline Interferometry) and are now trying to apply for EHT (Event Horizon telescope), which is a project to take pictures of super-massive Black holes. In this talk, we will explain our sparsity based methods and our projects.

Masanao Ozawa

Title: Quantum Measurement Theory,

the Uncertainty Principle and Gravitational Wave Detection: A Crossroad

Abstract:

In the 1960s two types for gravitational wave detectors were proposed: the resonator type detectors based on monitoring a harmonic oscillator position and the interferometer type detectors based on monitoring the free mass position. Up to 1980 it was a common opinion of the community in favor of the resonator type detectors that the uncertainty principle puts a sensitivity limit, called the standard quantum limit, for monitoring the free mass position, but not for monitoring the harmonic oscillator position. In this talk, we review a controversy during the 1980s over this common opinion, which resulted in the superiority of the interferometer type detectors and revisions of the uncertainty principle.

Philip B. Stark

Title: Quantifying Uncertainty in Inferences in Physics and Astronomy

Abstract:

Many physical parameters are functions of position, energy, time, or other continuous variables: the parameters are vectors in infinite-dimensional spaces. In general, estimates of such parameters from any finite set of data have unbounded bias. Some widely used methods obscure this uncertainty through truncation, discretization, or regularization, all of which introduce biases that are not taken into account in the formal error bars, resulting in faulty inferences and false optimism. While in general it is impossible to estimate the entire infinite-dimensional parameter, useful inferences about interesting functionals of the parameter may be possible, especially when the parameter satisfies a physical constraints such as nonnegativity, monotonicity and other shape restrictions, or a norm bound. One conservative, non-asymptotic method that is widely applicable is "strict bounds," which formulates constructing a confidence bound as a constrained infinite-dimensional optimization problem. Considering underlying scientific questions has also led to new optimality criteria for statistical methods, such as minimax regret expected size confidence sets and conservative confidence sets that preferentially avoid special values. I will give some positive and negative examples in geomagnetism, seismic tomography, helioseismology, microwave cosmology, Type Ia supernova cosmology, and high-energy physics.

Alessandro Sonnenfeld

Title: Bayesian hierarchical inference in astronomy

Abstract:

Bayesian hierarchical inference methods are quickly finding applications in a broad range of astronomical studies, in particular for the analysis of large and complex datasets.

In its simplest form, a Bayesian hierarchical approach to the study of a set of objects, such a large sample of galaxies, consists in creating a two-level

hierarchy of parameters: at the highest level there are parameters describing the object population as a whole, while at the bottom level are the parameters describing each individual object in the sample.

The former define the probability distribution from which the latter are drawn, which in turn determine the likelihood of observing the data.

All the parameters entering the problem are inferred at the same time, allowing for a more rigorous propagation of uncertainties and exploration of model degeneracies compared to some of the more traditional methods, which in turn results in a greater accuracy.

In addition, Bayesian hierarchical inference methods allow for greater precision, thanks to the effect of Bayesian shrinkage.

I will introduce the basic concepts of Bayesian hierarchical inference, and show some examples based on cosmic shear, galaxy-galaxy lensing and photometric redshift estimation: areas in which both Kavli IPMU and Berkeley are heavily involved.

Ippei Obayashi

Title: Introduction to topological data analysis

Abstract:

Topological data analysis (TDA) enables you to analyze data from the viewpoint of topology. Persistent homology (PH) is a significant tool for TDA. It extracts geometric features of data effectively and quantitatively.

In this talk, I will show you the theoretical foundation and applications of PH. I will also introduce a data analysis software of PH, Homcloud, developed by us.

Wahid Bhimji

Title: Deep learning for HEP and Cosmology

Abstract:

Machine learning has been used in HEP and Cosmology for some time but recently there has been considerable interest in application of deep neural networks to these fields. This has led not only to gains in sensitivity from existing physics-derived, high-level variables, but also enabled direct use of high-dimensional detector-level data, exploiting yet more information. Furthermore the potential applications are now going beyond supervised classification for identification of physics phenomena into areas such as unsupervised exploration of data and generation of simulated data. Achieving all this is increasingly pushing the methodological and computational boundaries of data-science. In this talk I'll describe recent activity in this field with heavy involvement from Berkeley scientists, as well as outlining some possible prospects for the future.